C_{60} In Boron Nitride Tubes Forms an Insulated Nanowire

A Materials Sciences Division group led by Alex Zettl has "stuffed" C_{60} "buckyballs" inside boron nitride nanotubes, fused the buckyballs, and in the process formed a conducting carbon nanotube encased within an outer sheath of non-conducting boron nitride – an insulated "nanowire."

Fullerenes, cagelike structures of carbon and other atoms, have been the subject of intense research since the Nobel Prize winning discovery of C_{60} in 1985. Carbon nanotubes are particularly interesting. Earlier LBNL work has shown that, depending on their exact structure, they can be metallic or semiconducting (Highlights 96-7 and 01-5) and can be used to make devices such as transistors (Highlight 00-9). An essential remaining step in the realization of practical integrated nanotube-based devices is the development of strategies to insulate the components from one another to prevent "cross talk" or electrical shorts.

The LBNL team addressed this challenge using insulating hollow boron nitride nanotubes, which they had discovered in 1995. A special heat treatment was used to open the tips of the tubes. C_{60} powder was added and, while heated in vacuum, it diffused into the BN wires, forming a close-packed structure.

The structure of the C_{60} packing was shown to depend on the inner diameter of the BN tube. In small diameter tubes, the C_{60} forms a linear or staggered chain, in agreement with theoretical predictions (see figure). At increasingly larger tube diameters, the staggered chain becomes close-packed, and then corkscrew-like. Exposure of the linear chain of C_{60} in the narrow tubes to an intense beam of electrons for 10 minutes fuses the C_{60} molecules into a 1.3 nm diameter continuous and crystalline carbon nanotube: a conductor enclosed within the world's strongest insulating fiber (the BN nanotube).

The ability to reliably insulate nanoscale conductors creates new possibilities for nanoelectronics. The insulating BN sheath prevents wires from shorting to each other or to nearby conductors, and will allow the wires to serve as the basis of coaxial cables or as simple gates for electronic devices such as transistors. The unusual C_{60} configurations in larger tubes have never been seen before in bulk or thin-film forms of C_{60} and are expected to have novel electrical and mechanical properties.

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W. Mickelson, S. Aloni, Wei-Qiang Han, John Cumings, and A. Zettl, "Packing C_{60} in Boron Nitride Nanotubes," *Science* **300**, 467 (2003).

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